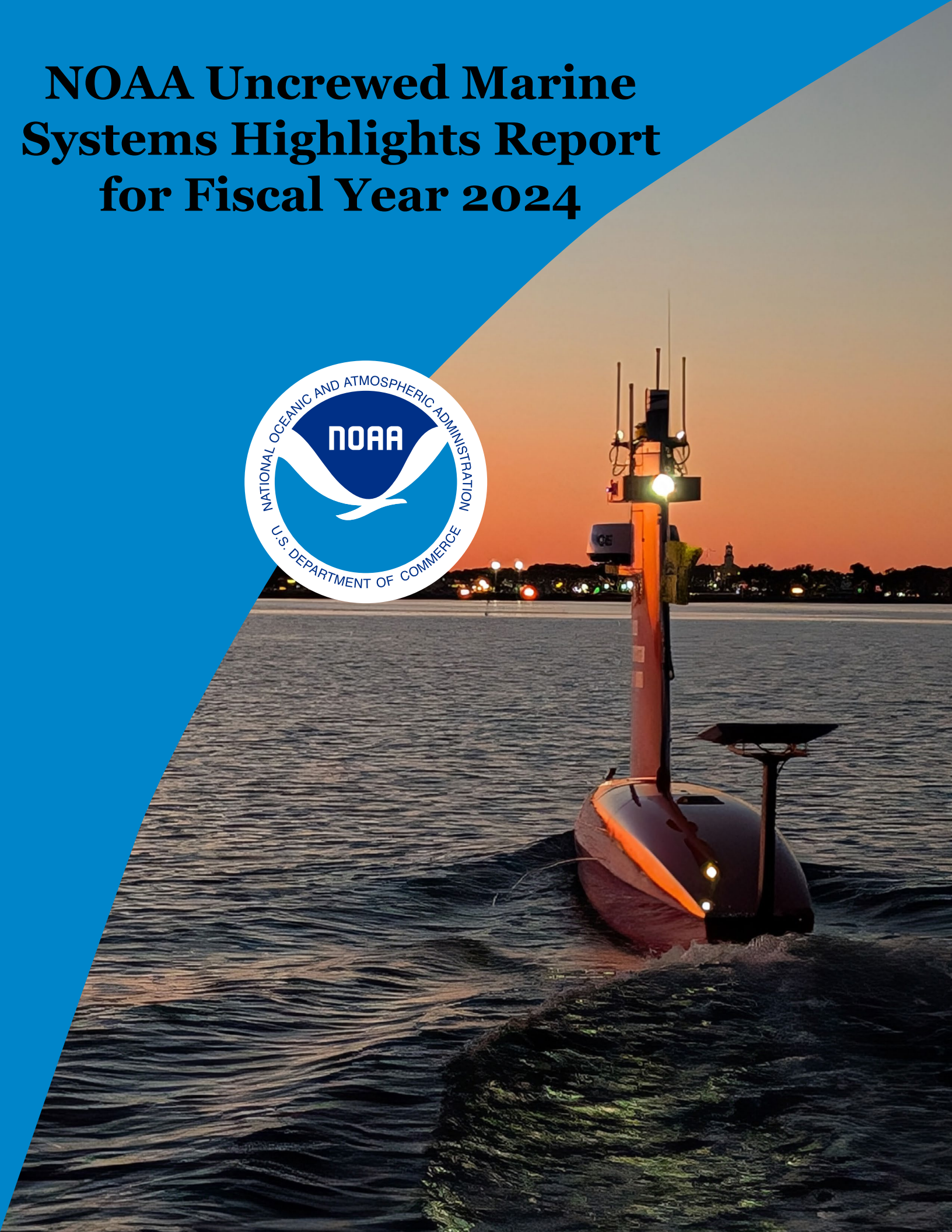
NOAA Uncrewed Marine Systems Highlights Report for Fiscal Year 2024



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Cover Photo: A DriX uncrewed surface vehicle in transit. Photo: University of New Hampshire/KG Fairbarn

About the National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA), under the Department of Commerce, provides science, service, and stewardship to protect life, property, and Earth's natural resources. By collecting scientific data, NOAA provides daily weather forecasts, storm warnings, and climate monitoring; and facilitates fisheries management, marine commerce, and coastal restoration. NOAA uncrewed systems work is organized into Uncrewed Aircraft Systems and Uncrewed Marine Systems (UMS).

About the Uncrewed Systems Executive Oversight Board

The Uncrewed Systems Executive Oversight Board provides oversight of NOAA's Uncrewed Aircraft Systems and UMS efforts. It assures agency-wide strategies and initiatives are developed collaboratively and implemented consistently. It was established through the Commercial Engagement through Ocean Technology Act of 2018. The Executive Oversight Board includes membership from across NOAA's line offices and reports to the NOAA Fleet Council. The Executive Oversight Board is co-chaired by the Office of Marine and Aviation Operations and Office of Oceanic and Atmospheric Research.

About the Uncrewed Systems Operations Center

The Uncrewed Systems Operations Center was established in Fiscal Year (FY) 2020, following receipt of funding to improve and expand uncrewed systems operations across NOAA. The Uncrewed Systems Operations Center sits within NOAA's Office of Marine and Aviation Operations and works to expand uncrewed systems applications, transition uncrewed systems into operational use, and provides corporate support to uncrewed systems operations. Within the Uncrewed Systems Operations Center sits the UMS Division that plays a central role in all NOAA UMS operations.

About the Annual Report

This Annual Report is an overview of the UMS work of NOAA in FY 2024. The information presented is structured to provide insight on NOAA UMS adoption, applications, and integration. This document was developed by the Uncrewed Systems Executive Oversight Board with support from the Uncrewed Systems Operations Center.

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Foreword

Dear Readers,

On behalf of the NOAA Uncrewed Systems Executive Oversight Board, we are pleased to share with you NOAA's Uncrewed Marine Systems (UMS) Highlights Report for Fiscal Year (FY) 2024. UMS has become a valuable tool for NOAA in meeting its science, service, and stewardship mission. As a result, the Agency engages in the research, development, testing, evaluation, and transition to operations of UMS to meet mission needs. Operationalized UMS have become another tool in NOAA's tool kit of environmental observation assets. Partnership is key to NOAA's innovative use of UMS, and the Agency regularly collaborates with other government, industry, and academic groups to accelerate NOAA's adoption of UMS. This report contains numerous examples of NOAA's UMS-enabled work, UMS partnerships, and innovative thinking surrounding UMS over the last year.

In FY 2024, NOAA deployed UMS across the U.S. Exclusive Economic Zone, enabling efficient and effective acquisition of environmental observations. This report features examples of this effort including using UMS to: combat illegal, unreported, and unregulated fishing; map the seafloor; gather oceanographic and atmospheric measurements from hard to access regions, and inform weather forecasts. As a steward of environmental data, NOAA also improved data management and data sharing practices for UMS in FY 2024. Collectively, these efforts highlight the talented and dedicated NOAA workforce behind all UMS efforts.

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Rear Admiral Chad Cary (*on behalf of Rear Admiral Amanda Goeller*) & CAPT Bill Mowitt

NOAA Uncrewed Systems Executive Oversight Board Co-chairs

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Executive Summary

This report is the second iteration of the Uncrewed Marine Systems (UMS) Highlights Report, and specifically focuses on NOAA's UMS activities in Fiscal Year (FY) 2024.

This report contextualizes NOAA's use of UMS across NOAA's six line offices and the two program offices indicated in the Commercial Engagement through Ocean Technology Act of 2018 as critical to NOAA's UMS activities.

Line Offices:

- Office of Marine and Aviation Operations (OMAO)
- Office of Oceanic and Atmospheric Research (OAR)
    - Program Office: Ocean Exploration (OE)
- National Marine Fisheries Service (NMFS)
- National Weather Service (NWS)
- National Ocean Service (NOS)
    - Program Office: Integrated Ocean Observing System (IOOS)
- National Environmental Satellite Data and Information Service (NESDIS)

This contextualization occurs through office-specific vignettes that highlight the breadth and depth of UMS-related work conducted by NOAA. Vignettes feature the development and operations of UMS within hurricanes, to support fisheries management, gather oceanographic and atmospheric data, and more. They cover work across the entire U.S. Exclusive Economic Zone, and also consider the best operating models for UMS and the management of collected data.

NOAA Program FY 2024 Highlights

The Future of Ocean Data: Uncrewed Systems and Enhanced Global Access

Lead Personnel: Jennifer Bowers, Katharine Weathers, Andrew Evans- NESDIS National Centers for Environmental Information

Effective data management and data sharing are vital for improving weather forecasts, fisheries management, nautical charting, and other critical applications. Given the central role data plays for NOAA's missions, it is essential to ensure accurate and timely data storage and retrieval for national safety.

The National Centers for Environmental Information (NCEI) uncrewed systems data team; in partnership with various organizations including the United States Navy, Saildrone, and the University of Southern Mississippi is developing advanced data pipelines for UMS data. Ensuring the completeness of these pipelines is crucial for NOAA's ability to route oceanographic and atmospheric data from collection through mission support activities to long-term preservation and reuse. The team is currently supporting efforts to enhance the pipelines that support hurricane forecasting and tropical Pacific observations. They achieve this by strengthening NOAA data value chains, routing real-time and delayed-mode data from sources such as the IOOS Glider Data Assembly Center, Saildrone, and the Tropical Pacific Observing System. At NCEI, the data undergoes rigorous archiving, quality control, and dissemination.

Initiatives like this will not only enhance the accuracy of weather predictions but also facilitate easy global access to data. As these automated systems evolve, the integration of real-time ocean and atmospheric data will transform weather forecasting and disaster response capabilities, ultimately saving lives and reducing property damage during extreme weather events.

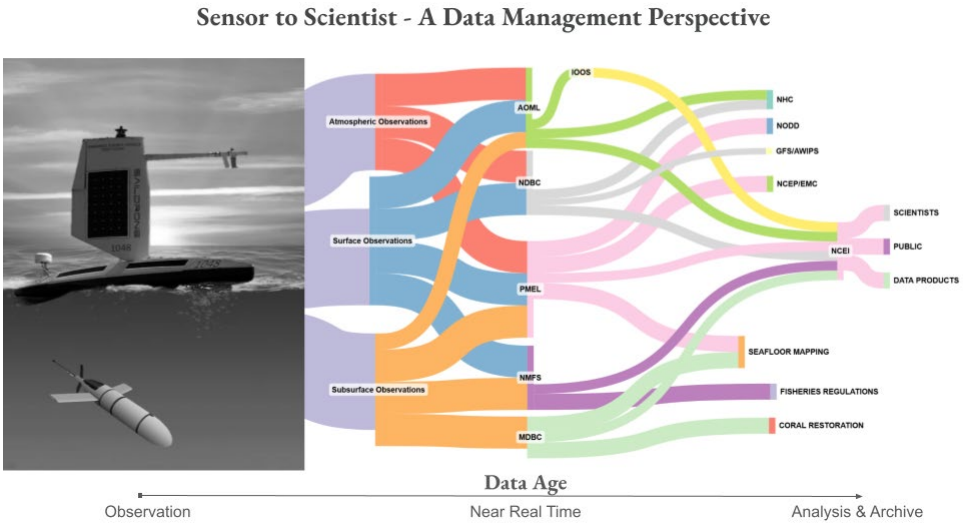

Image 1: Example of how data collected from uncrewed systems is routed through near real time availability at line offices and labs to analysis and archive at NCEI. Photo: NOAA

Developing a 'System of Systems' for IUU Fishing Detection

Lead Personnel: Todd Jacobs– NOS Office of National Marine Sanctuaries

Illegal, Unreported, and Unregulated (IUU) fishing is a global problem necessitating innovative approaches for detection and enforcement. To address this, researchers from NOAA's Office of National Marine Sanctuaries and Southeast Fisheries Science Center have partnered with Thayer Mahan in a study funded through NOAA Fisheries Office of Law Enforcement to evaluate and integrate UMS technologies into maritime domain awareness and surveillance operations.

Imager 2: Example Thayer Mahan Outpost UMS that will be incorporated into the 'system of systems'. Photo: Thayer Mahan

Effective maritime law enforcement requires real-time, high-resolution data to identify and track vessels engaged in IUU activities. It requires maintaining a secure chain of custody for collected data for legal action. However, there are not enough crewed ships to monitor across potential IUU fishing areas.

This initiative tests and evaluates using a network of uncrewed systems to detect, report, and collect evidence of IUU fishing. Two long duration uncrewed surface vessels are equipped with advanced hydroacoustic arrays that listen for vessel activity, with a third equipped with advanced cameras to capture evidence of illegal activity and contacts of interest. The path of these UMS are informed by intelligence gathered via the Allen Institute for Artificial Intelligence Skylight system and Thayer Mahan's maritime surveillance systems. Contacts of interest are reported in near real-time to the Naval Research Laboratory's Proteus system for NOAA oversight and decision making. The project delivers a low cost, contractor operated, and globally deployable sensing network that amplifies NOAA's law enforcement capability without additional staffing, training, or equipping cost.

A field demonstration is planned between June and September 2025. The demonstration will showcase the operational capabilities of UMS technologies in detecting and deterring IUU fishing activities.

The Utilization of UMS Data for the National Hurricane Center

Lead Personnel: Wallace Hogsett, Daniel Brown – NWS National Hurricane Center

The NOAA National Hurricane Center's (NHC) mission is to issue the best watches, warnings, forecasts, and analyses of hazardous tropical weather to protect lives and property. In that vein, the NHC is exploring the use of UMS data to enhance hurricane forecasting and improve our understanding of these storm systems. While still in the early stages, NHC is exploring the utilization of uncrewed surface vehicle and glider data for situational awareness of forecasters and in marine forecasts and analyses.

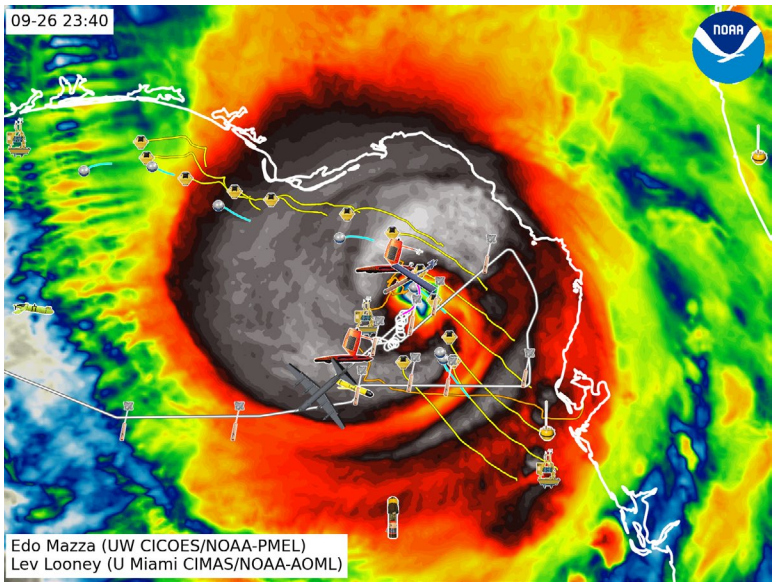

Image 3: Graphic depicting various uncrewed and crewed assets deployed in Hurricane Helene to gather data. Photo: Edo Mazza/Lev Looney/NOAA

Saildrone uncrewed surface vehicle and glider data collected over recent hurricane seasons has been valuable in analyzing wind fields, tropical storm and hurricane-force winds, and the size and impact of storms. It has also helped assess wave height and wave field extent, which is crucial for mariners' safety in that it improves ship routing and forecasting of coastal dangers. The data also provides insights into storm structure, intensity, and size to help predict storm impacts and identify the development of tropical storms. It also assists with model guidance, improving intensity and structure predictions every six hours. Although the technology is still being refined, UMS has proven to be able to provide critical near-surface data in hurricane conditions.

In collaboration with NOAA's Environmental Modeling Center, and utilizing data distribution from NOAA's National Data Buoy Center, UMS data is being integrated into forecasting systems to enhance storm predictions. This work is part of a larger effort to incorporate uncrewed technology into operational forecasting models for more accurate forecasts and improved storm warnings.

Observing the Tropical Pacific with Saildrones

Lead Personnel: Meghan Cronin – OAR Pacific Marine Environmental Laboratory

Monitoring air-sea interactions in the tropical Pacific Ocean is crucial for understanding and predicting global weather patterns. Continuous data collection helps predict extreme weather events and supports sustainable marine practices, which are key missions of NOAA. In a cross-NOAA collaboration involving NOAA's Pacific Marine Environmental Laboratory, National Centers for Environmental Prediction's Climate Predict Center and Environmental Modeling Center, Pacific Island Fisheries Science Center, and National Data Buoy Center, NOAA has deployed saildrone uncrewed surface vehicles to the tropical Pacific since 2017. The purpose of these deployments is to test how UMS could be integrated into the Tropical Pacific Observing System to improve ocean products and enhance forecasts.

Efforts in 2023 and 2024 were able to track developing El Niño and La Niña conditions in the central equatorial Pacific where these conditions originate from, and then impact global weather. Real-time data was transmitted through the National Data Buoy Center to global forecasting centers for assimilation into El Niño predictions. Along with measuring atmospheric and oceanographic conditions, the saildrones also conducted fisheries observations to support NOAA's fisheries management goals. During this mission, the saildrones were able to perform a fortuitous one-day intercomparison against biological and physical measurements made aboard the French ship R/V Antea. These missions highlight the value of UMS in gathering data from remote areas.

Image 4: Saildrone 1090 departs San Francisco Bay on September 16, 2024 at the start of the Tropical Pacific Observing System mission. Photo: NOAA

Advancing Safe Operations with DriX Uncrewed Surface Vehicles

Lead Personnel: Joshua Bergeron - OMAO UMS Division

In 2023, NOAA operationalized the DriX uncrewed surface vehicle to perform hydrographic surveys. As UMS become more routine tools in such surveys, ensuring safe and reliable operations is crucial. As a result, the NOAA UMS Division is working with government, industry, and academic partners to develop operator trainings and consider best practices for UMS use in the maritime system. In 2024, the NOAA UMS Division developed qualification standards for DriX operators, supervisors, and master operators, and ran the first NOAA-run DriX operator course. The implementation of safe operational practices and development of UMS operator trainings will set a standard for both NOAA and the broader maritime community in UMS operations.

In 2024, several key surveys using DriX were conducted. The NOAA Ship *Thomas Jefferson* Approaches to Savannah survey used a DriX to replace a traditional survey launch, improving survey efficiency. In addition, a shore-based project deployed two DriX units simultaneously from a remote operations center, testing personnel needs and operational efficiency. A DriX from shore effort was also conducted in American Samoa with the Ocean Exploration Cooperative Institute.

Image 5: Two DriX transit with a University of New Hamsphire research vessel in preparation for operations. Photo: NOAA/Ocean Exploration Cooperative Institute/University of New Hampshire

Future plans include a summer 2025 hydrographic survey off the NOAA Ship *Thomas Jefferson*. As DriX become an important tool for UMS operations, NOAA will continue to lead the way in developing best practices for UMS operations. The team's work on training programs and remote operation standards will influence the entire industry, ensuring that UMS become a reliable and efficient part of hydrography surveys, ocean exploration, and environmental monitoring in the years ahead.

Enhancing UMS use to Explore American Samoa

Lead Personnel: Aurora Elmore - OAR Ocean Exploration

UMS is revolutionizing the exploration and mapping of the ocean floor. These systems enable access to previously inaccessible deep-water locations, significantly enhancing our understanding of marine ecosystems, underwater maritime heritage, seabed resources, and geological features.

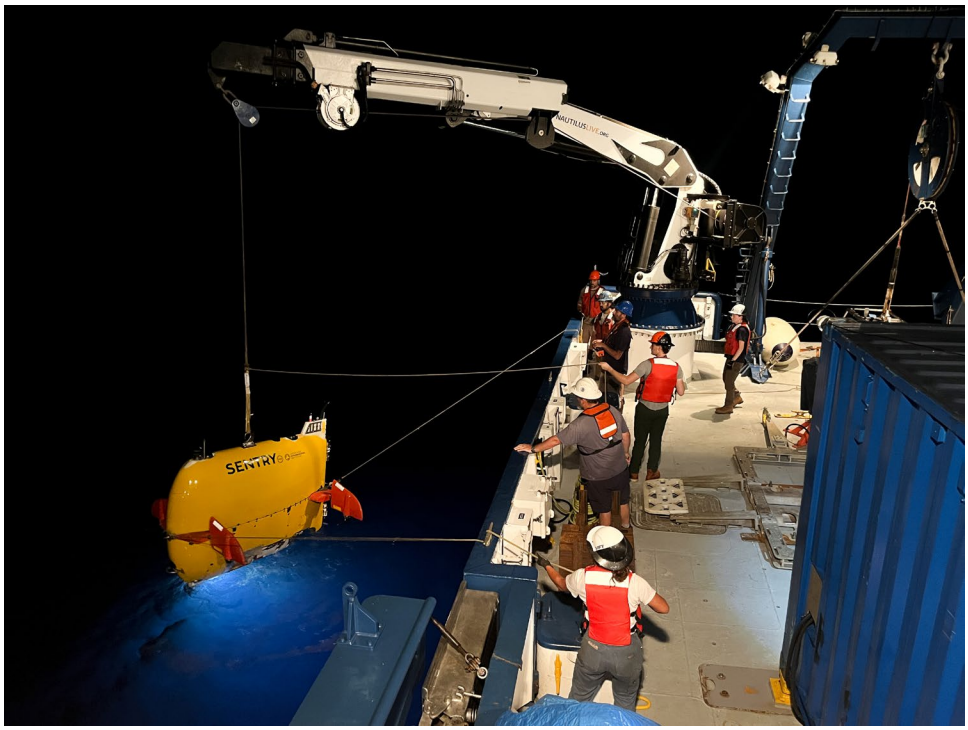

Image 6: AUV Sentry being lowered into othe ocean before a dive. Photo: NOAA Ocean Exploration Cooperative Institute

In September 2024, NOAA Ocean Exploration and the Ocean Exploration Cooperative Institute conducted an expedition in American Samoa to search for the Samoan Clipper wreck site, characterize abyssal plain habitats and geology, and study hydrothermal venting near Vailulu'u Seamount, within the National Marine Sanctuary of American Samoa. Autonomous underwater vehicle (AUV) Sentry completed 10 successful dives, totaling over 142 hours and covering more than 192 miles, gathering data at depths up to 3 miles. AUV Sentry carried newly developed programs that guided its existing chemical sensors in detecting hydrothermal seeps, which is an advancement in detecting these dynamic features. Deepwater AUV operations in prospective marine critical mineral areas were funded in partnership with the Bureau of Ocean Energy Management.

This mission highlights the transformative potential of UMS in ocean exploration. As technology progresses, these systems will enable deeper and more detailed investigations, enhancing scientific understanding and further contributing to NOAA science, service, and stewardship.

2024 Hurricane Glider Season

Lead Personnel: Kathleen Bailey–NOS Integrated Ocean Observing System

Accurate hurricane forecasting is essential for saving lives and protecting property. NOAA and partners, led by the U.S. Integrated Ocean Observing System, deploy gliders throughout U.S coastal waters to gather oceanographic data that feeds hurricane intensity forecasts, and that improves our understanding of hurricane intensity, leading to better predictions and greater preparedness for coastal communities.

Image 7: A glider descends into the ocean on a deployment. Photo: Jackson Schroeder/ University of Georgia

During the 2024 hurricane season, gliders were strategically positioned to track ocean features linked to storm intensification or weakening, and to monitor upper ocean conditions throughout the season. The data filled critical observing gaps in the upper ocean, which is a data-sparse region. The program brought 130,839 temperature and salinity profiles into NOAA from 104 deployments, monitoring conditions for 4,299 glider days at sea. The data were submitted to the IOOS Glider Data Assembly Center and delivered by the National Data Buoy Center to the Global Telecommunications System for ingestion into global forecast models. Gliders were positioned inside the 5-day forecast cone for seven tropical cyclones and five major hurricanes, with glider data assimilated into models for 100 percent of hurricanes that made landfall in the United States. Glider operations were also coordinated with nearby saildrones and Hurricane Hunter aircraft to gather complementary observations in close proximity.

The data gathered during the 2024 season highlights the vital role of UMS in hurricane forecasting. With over 840,000 glider profiles collected since 2018, the program continues to refine its techniques and expand its capabilities. The 2024 season was the first season that gliders from the Pacific Islands IOOS Regional Association captured ocean data ahead of tropical cyclones. Future deployments will continue to help reduce error in hurricane intensity forecasts, and are expected to further improve the models, potentially saving more lives and reducing the economic impact of future hurricanes.